



## Curriculum Vitae

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publications: <http://scholar.google.com/citations?user=ABILhYAAAAJ>

## Appointments

### LEHIGH UNIVERSITY - 2010-Present

Professor of Physics

### LEHIGH UNIVERSITY - 2002-0210

Associate Professor of Physics

### ETH ZURICH - 2001-2002

Private Lecturer. The Private lecturer (Privatdozent, P.D.) in the german system is one who is habilitated to teach at the university level, and holds the *venia legendi*.

### ETH ZURICH - 1996-2002

Team Leader in the nonlinear optics Laboratory (photonic materials technologies Team). Directed work on organic semiconductors and fundamentals of OLED materials and systems.

### INSTITUT D'OPTIQUE, ORSAY, FRANCE - 1995

Postdoctoral fellow with Prof. G. Roosen. Worked on photorefractive crystals such as CdTe for infrared dynamic holography, and developed a new Monte Carlo analysis of the effect of AC electric fields and shallow traps on the buildup of holographic gratings.

### UNIVERSITY OF SOUTHERN CALIFORNIA - 1993-1994

Postdoctoral fellow with Prof. R. W. Hellwarth. Worked on nonlinear optics of atomic gases, and developed an ultrafast optical correlator based on degenerate four-wave mixing in atomic vapors.

### ETH ZURICH - 1986-1992

Research Assistant in the nonlinear optics Laboratory, with Prof. P. Günter. Research on photorefractive effects and nonlinear optics, teaching.

## Visiting Positions

### **UNIVERSITY OF SCIENCE AND TECHNOLOGY, CHINA - March 2014**

Taught a Nonlinear Optics Course for 150 graduate students.

### **UNIVERSITÉ DE LORRAINE, METZ, FRANCE - July 2013 and 2014**

Collaborated with Prof. Montemezzani to develop second and third-order Coupling Length Phase Matching (CLPM) in parallel waveguides.

### **UNIVERSITY OF SOUTHERN CALIFORNIA - September 1998**

Collaborated with Prof. Hellwarth to complete our work on expanding the classic Feynman-Hellwarth-Iddings-Platzman approach to the the case of large polarons in a multimode polar lattice.

### **NATIONAL INSTITUTE FOR RESEARCH IN INORGANIC MATERIALS, TSUKUBA, JAPAN - February 1998**

With Prof. Kenji Kitamura. Worked on using holography for studying photoconductivity in recently grown bismuth germanate crystals.

### **UNIVERSITY OF SOUTHERN CALIFORNIA - April-May 1996**

With Prof. R. Hellwarth. Used Holographic Time of Flight in Diffusion Mode for the successful determination of photocarrier mobility in bismuth silicon oxide, including its temperature dependence, and a corresponding physical model based on a modification of the famous Feynman-Hellwarth-Iddings-Platzman large polaron analysis to the case of a multimode polar lattice, which proved that photoexcited electrons in this material form large polarons.

### **UNIVERSITY OF SOUTHERN CALIFORNIA - March 1995**

With Prof. R. Hellwarth. Initiated work on using Holographic Time of Flight in Diffusion Mode to study the mobility of photoexcited carriers in bismuth silicon oxide.

## Education

### **HABILITATION IN EXPERIMENTAL PHYSICS - ETH Zurich, 2000**

*"Nonlinear Optical Wave interaction in Noncentrosymmetric Materials: Sub-Nanosecond Charge Migration and Degenerate Four Wave Mixing,"* with Prof. P. Günter and Prof. T.M. Rice (in the german system, the Habilitation is a kind of "super-doctorate")

### **PH.D. IN PHYSICS - ETH Zurich, 1993**

Ph.D. Dissertation with Prof. Günter and Prof. Melchior: *"Photorefractive Effects Induced by Short Light Pulses"*.

### **DIPLOMA (MS) IN PHYSICS - ETH Zurich, 1986**

Master thesis with Prof. F.K. Kneubühl: *"Mode Structure of a Helical Feedback Gas Laser"*.

## Professional Recognition and Activities

### HONORS AND AWARDS

- ▶ Elected Fellow of the Optical Society of America (OSA), 2020.
- ▶ Named the Joseph A. Waldschmitt Endowed Chair in Physics. Lehigh University, 2017.
- ▶ Recipient of The 2008 Eleanor and Joseph F. Libsch Early Career Research Award. Lehigh University.
- ▶ Inducted into Sigma Xi (2003).
- ▶ Venia legendi (Habilitation) in experimental physics. ETH Zurich, 2001.
- ▶ Stefano Franscini Fellowship. Swiss National Science Foundation, 1993-1994.

### PROFESSIONAL SOCIETIES, SERVICE ACTIVITIES, AND COMMITTEE WORK

- ▶ Fellow of the Optical Society of America (OSA). Member of the Swiss Physical Society.
- ▶ Member of the Editorial Board of "Optical Materials Express," OSA's open access Journal that focuses on advances in novel optical materials (2014-present).
- ▶ Feature Editor: Nonlinear Optics joint feature issue in Optical Materials Express and Optics Express (2017-2018).
- ▶ Editor: feature issue of the Journal of the Optical Society of America B: "Nonlinear Optics Near the Fundamental Limit," (2016).
- ▶ Member of the program committee for Frontiers in Optics, the Optical Society of America's annual meeting. Integrated Photonics Subcommittee. (2012 - 2015).
- ▶ Member of the Technical Program Committee of ICONO 2017, the 13th International Conference on Organic Nonlinear Optics.
- ▶ FoNLO, "Foundations of Nonlinear Optics" Meetings. Chairman and organization of FoNLO 2015 at Lehigh University. Organizing and program committee for FoNLO 2016-2019.
- ▶ International Organizing Committee, Program Coordinator, and webmaster for ICONO'5, the fifth international conference on organic nonlinear optics, Davos, Switzerland, 2000. ([www.icono5.ethz.ch](http://www.icono5.ethz.ch))
- ▶ Service on the International Organizing Committee of the EOS Topical Meeting "Organic Optoelectronics: Technology and Devices," Engelberg, Switzerland, 2002
- ▶ Consulting work for Corning, Lightwave Logic, Lehighon Electronics.

## Expertise and Areas of Specialization

Laser physics, Condensed Matter Physics, and Material Science. Short pulse lasers and their applications. Optical investigation techniques such as absorption and photoluminescence spectroscopy. Pump&probe techniques, in particular when applied to transient gratings in degenerate four-wave mixing experiments. Time-resolved photoconductivity and photoluminescence. Molecular beam deposition of organic materials. Ferroelectric materials, perovskites, polar crystals, organic semiconductors. All-optical investigation of charge transport in electro-optic materials using pulsed holographic techniques.

Nonlinear Optics. Second and third order nonlinear optical effects in noncentrosymmetric crystals, organic molecules, and organic bulk materials. Experimental methods for the characterization of nonlinear optical susceptibilities and hyperpolarizabilities.

Photorefractive effect in electro-optic photoconductors and its use in dynamic holography, beam coupling, and phase conjugation. Photorefractive materials such as BaTiO<sub>3</sub>, KNbO<sub>3</sub>, Bi<sub>12</sub>SiO<sub>20</sub>, Sn<sub>2</sub>P<sub>2</sub>S<sub>6</sub>.

## Original Contributions

Introduced a new paradigm for creating third-order nonlinear optical materials using dense supramolecular assemblies of optimized small molecules. This led to the demonstration of the first silicon-organic hybrid waveguide that could demultiplex a 170 Gbit/s data stream on the silicon photonics platform. *See key representative publications: Organic materials for third order nonlinear optics.*

Invented new methods for optical studies of exciton dynamics in organic semiconductors, in particular the direct quantitative observation of triplet exciton diffusion in an organic single crystal by imaging the photoluminescence created by triple-triplet interaction. This was the first ever direct optical observation of exciton diffusion processes in organic crystals. Also, first detection of fluorescence quantum beats in rubrene. *See key representative publications: Exciton dynamics and organic semiconductors.*

Developed the first full analysis and characterization of second order cascaded contributions to degenerate four-wave mixing. *See key representative publications: Cascading in four-wave mixing.*

Inventor of the Holographic Time of Flight Method in diffusion mode for the all-optical investigation of carrier mobilities. This was the first all-optical contact-less method to study mobilities of a low concentration of charge carriers with nanosecond and sub-nanosecond lifetimes and over sub-micrometer transport lengths. *See key representative publications: Contactless studies of charge transport.*

Creation of various novel optical techniques: phase-matched multi-wave mixing for the characterization of refractive index dispersion, non-collinear third-harmonic Maker Fringes for eliminating the contribution of air when determining third-order susceptibilities, degenerate four wave mixing for the spectroscopy of the third-order polarizability, coupling-length phase matching for nonlinear optical frequency conversion in parallel waveguides, nonlinear optical interaction in atomic vapors for image correlation. Also co-inventor of oblique incidence organic molecular beam deposition to fabricate oriented molecular films. *See key representative publications: Development of optical techniques.*

## Key Representative Publications

### ORGANIC MATERIALS FOR THIRD ORDER NONLINEAR OPTICS

Publications related to the development of a new paradigm for creating a flexible, high optical quality third-order nonlinear optical material for integrated optics by using dense supramolecular assemblies of optimized small molecules.

M. A. Erickson, M. T. Beels, and I. Biaggio, "Optimum conjugation length in donor-acceptor molecules for third-order nonlinear optics," *J. Opt. Soc. Am. B* 33, E130-E142 (2016).

C. Koos, P. Vorreau, T. Vallaitis, P. Dumon, W. Bogaerts, R. Baets, B. Esembeson, I. Biaggio, T. Michinobu, F. Diederich, W. Freude, J. Leuthold, "All-optical high-speed signal processing with silicon-organic hybrid slot waveguides," *Nature Photonics* 3, 216 - 219 (2009).

B. Esembeson, M. L. Scimeca, I. Biaggio, T. Michinobu, F. Diederich, "A High Optical Quality Supramolecular Assembly for Third-Order Integrated Nonlinear Optics," *Adv. Mater.* 19, 1-4 (2008).

J. C. May, I. Biaggio, F. Bures, F. Diederich, "Extended conjugation and donor-acceptor substitution to improve the third-order optical nonlinearity of small molecules," *Appl. Phys. Lett.* 90, 251106 (2007).

### EXCITON DYNAMICS AND ORGANIC SEMICONDUCTORS

Publications related to the experimental investigation of the fundamental physics of excitonic processes (such as triplet fusion and singlet fission) in organic molecular crystals. This work cleared up several misunderstandings in the literature, in particular in regards to the rubrene crystal.

Eric A. Wolf, Drew M. Finton, Vincent Zoutenbier, Ivan Biaggio, "Quantum beats of a multiexciton state in rubrene single crystals," *Appl. Phys. Lett.* 112, 083301 (2018)

P. Irkhin, I. Biaggio, T. Zimmerling, M. Döbeli, B. Batlogg, "Defect density dependent photoluminescence yield and triplet diffusion length in rubrene," *Appl. Phys. Lett.* 108 (6), 063302 (2016).

I. Biaggio, P. Irkhin, "Extremely efficient exciton fission and fusion and its dominant contribution to the photoluminescence yield in rubrene single crystals," *Appl. Phys. Lett.* 103(26), 263301 (2013).

P. Irkhin and I. Biaggio, "Absorption and photoluminescence spectroscopy of rubrene single crystals," *Phys. Rev. B* 86, 085143 (2012).

A. Rysanyanskiy and I. Biaggio, "Triplet exciton dynamics in rubrene single crystals," *Phys. Rev. B* 84, 193203 (2011).

P. Irkhin and I. Biaggio, "Direct imaging of anisotropic exciton diffusion and triplet diffusion length in rubrene single crystals," *Phys. Rev. Lett.* 107, 017402 (2011).

H. Najafov, I. Biaggio, V. Podzorov, M. F. Calhoun, M. E. Gershenson, "Primary Photoexcitations and the Origin of the Photocurrent in Rubrene Single Crystals," *Phys. Rev. Lett.* 96, 0566004 (2006).

#### **CASCADING IN FOUR-WAVE MIXING**

Publications related to the theoretical and experimental study of cascaded second order contributions to degenerate four-wave mixing in acentric material. This was the first complete study of how optical rectification and electro-optic effect, or second harmonic generation and difference-frequency generation, create non-local geometry-dependent contributions to four-wave mixing.

I. Biaggio, "Degenerate four-wave mixing in noncentrosymmetric materials," *Phys. Rev. A* 64, 063813 (2001).

I. Biaggio, "Piezoelectric Contributions to Pulsed Degenerate Four Wave Mixing," *Appl. Phys. Lett.* 78(13), 1861 (2001).

I. Biaggio, "Nonlocal Contributions to Degenerate Four Wave Mixing in Noncentrosymmetric Materials," *Phys. Rev. Lett.* 82, 193-196 (1999).

#### **CONTACTLESS STUDIES OF CHARGE TRANSPORT**

Publications related to the development and application of holographic pump&probe techniques for the investigation of charge transport in electro-optic materials, allowing the study of charge-carrier mobilities on the nanosecond and sub-nanosecond time scale and over transport lengths of micrometers or less.

A. Regmi, A. Ganjoo, D. Zhao, H. Jain, and I. Biaggio, "Fast excited state diffusion in a-As<sub>2</sub>Se<sub>3</sub> chalcogenide films," *Appl. Phys. Lett.* 101, 061911 (2012).

M Wintermantel, I Biaggio, "Temperature Dependent Electron Mobility and Large Polaron Charge Transport in Bi<sub>12</sub>SiO<sub>20</sub>," *Phys. Rev. B* 67, 165108 (2003).

P Bernasconi, I Biaggio, M Zgonik, P Günter, "Anisotropy of the electron and hole drift mobility in KNbO<sub>3</sub> and BaTiO<sub>3</sub>," *Phys. Rev. Lett.* 78, 106 (1997).

I. Biaggio, R. W. Hellwarth, J. P. Partanen, "Band Mobility of Photoexcited Electrons in Bi<sub>12</sub>SiO<sub>20</sub>," *Phys. Rev. Lett.* 78, 891-894 (1997).

I Biaggio, M Zgonik, P Günter, "Photorefractive effects induced by picosecond light pulses in reduced KNbO<sub>3</sub>," *J. Opt. Soc. Am. B* 9, 1480 (1992).

#### **DEVELOPMENT OF OPTICAL TECHNIQUES**

Publications related to the development and demonstration of various new materials or techniques related to optical and nonlinear optical effects.

M. T. Beels, I. Biaggio, T. Reekie, M. Chiu, F. Diederich, "Two-photon absorption and spectroscopy of the lowest two-photon transition in small donor-acceptor substituted organic molecules," *Phys. Rev. A* 91, 043818 (2015).

I. Biaggio, V. Coda, G. Montemezzani, "Coupling-length phase matching for nonlinear optical frequency conversion in parallel waveguides," *Phys. Rev. A* 90, 043816 (2014).

I. Biaggio, M.S. Fleischman, "Noncollinear Third Harmonic Maker Fringes for the Determination of Third-Order Nonlinear Optical Susceptibilities," *Opt. Lett.* 38(21), 4461 (2013).

Z. Jin, C. Kan, U. B. Szafruga, J. Toulouse, I. Biaggio, "Three-color nonlinear optical mixing for the determination of the refractive index dispersion of a tellurite glass," *Appl. Phys. Lett.* 97, 131104 (2010).

A Schneider, I Biaggio, P Günter, "Terahertz-induced lensing and its use for the detection of terahertz pulses in a birefringent crystal," *Appl. Phys. Lett.* 84, 2229 (2004).

I Biaggio, JP Partanen, B Ai, RJ Knize, RW Hellwarth, "Optical image processing by an atomic vapour," *Nature* 371, 318 (1994).

## Representative publications of the last 10 years

The full list is available at <http://www.lehigh.edu/~ivb2/publications.html> and on google scholar at <https://scholar.google.com/citations?user=ABILlhYAAAAJ>.

- DM Finton, EA Wolf, VS Zoutenbier, KA Ward, I Biaggio, "Routes to singlet exciton fission in rubrene crystals and amorphous films," *AIP Advances* 9 (9), 095027 (2019).
- R Nuansri, P Buranasiri, HD Ou-Yang, I Biaggio, "Dielectrophoresis and colloidal phase transitions for ultra-broadband optical limiting," *Optics letters* 44 (15), 3801-3804 (2019).
- Eric A. Wolf, Drew M. Finton, Vincent Zoutenbier, Ivan Biaggio, "Quantum beats of a multiexciton state in rubrene single crystals," *Appl. Phys. Lett.* 112, 083301 (2018).
- Michael A. Erickson, Marten T. Beels, and Ivan Biaggio, "Optimum conjugation length in donor-acceptor molecules for third-order nonlinear optics," *J. Opt. Soc. Am. B* 33, E130-E142 (2016).
- A Regmi, I Biaggio, A. A. Grabar, "Optical determination of the charge carrier mobility in Sn<sub>2</sub>P<sub>2</sub>S<sub>6</sub>," *Appl. Phys. Lett.* 109(18), 182104 (2016).
- P Irkhin, I Biaggio, T Zimmerling, M Döbeli, B Batlogg, "Defect density dependent photoluminescence yield and triplet diffusion length in rubrene," *Appl. Phys. Lett.* 108(6), 063302 (2016).
- K. A. Ward, B. R. Richman, I. Biaggio, "Nanosecond pump and probe observation of bimolecular exciton effects in rubrene single crystals," *Appl. Phys. Lett.* 106(22), 223302 (2015).
- M. T. Beels, I. Biaggio, T. Reekie, M. Chiu, F. Diederich, "Two-photon absorption and spectroscopy of the lowest two-photon transition in small donor-acceptor substituted organic molecules," *Phys. Rev. A* 91, 043818 (2015).
- I. Biaggio, V. Coda, G. Montemezzani, "Coupling-length phase matching for nonlinear optical frequency conversion in parallel waveguides," *Phys. Rev. A* 90, 043816 (2014).
- P. Irkhin, I. Biaggio, "Two-photon absorption spectroscopy of rubrene single crystals," *Phys. Rev. B* 89, 201202(R) (2014).
- I. Biaggio, P. Irkhin, "Extremely efficient exciton fission and fusion and its dominant contribution to the photoluminescence yield in rubrene single crystals," *Appl. Phys. Lett.* 103(26), 263301 (2013).
- I. Biaggio, M.S. Fleischman, "Noncollinear Third Harmonic Maker Fringes for the Determination of Third-Order Nonlinear Optical Susceptibilities," *Opt. Lett.* 38(21), 4461-4464 (2013).
- I. Biaggio, "Small molecule supramolecular assemblies for third-order nonlinear optics," in: *Handbook of organic materials for optical and (opto)electronic devices*, Woodhead Publishing, pp. 170-189 (2013).
- I. Biaggio, "Short-pulse induced photocurrent and photoluminescence in organic materials," in: *Handbook of organic materials for optical and (opto)electronic devices*, Woodhead Publishing, pp. 356-376 (2013).
- P. Irkhin, A. Rysanskiy, M. Koehler, I. Biaggio, "Absorption and photoluminescence spectroscopy of rubrene single crystals," *Phys. Rev. B* 86, 085143 (2012).
- A. Regmi, A. Ganjoo, D. Zhao, H. Jain, and I. Biaggio, "Fast excited state diffusion in a-As<sub>2</sub>Se<sub>3</sub> chalcogenide films," *Appl. Phys. Lett.* 101, 061911 (2012).
- A. Rysanskiy and I. Biaggio, "Triplet exciton dynamics in rubrene single crystals," *Phys. Rev. B* 84, 193203 (2011).
- T. Ignatova, H. Najafov, A. Rysanskiy, I. Biaggio, M. Zheng, S. V. Rotkin, "Significant FRET between SWNT/DNA and Rare Earth Ions: A Signature of Their Spatial Correlations," *ACS Nano* 5(7), 6052-6059 (2011).
- P. Irkhin and I. Biaggio, "Direct imaging of anisotropic exciton diffusion and triplet diffusion length in rubrene single crystals," *Phys. Rev. Lett.* 107, 017402 (2011).
- Z. Jin, C. Kan, U. B. Szafruga, J. Toulouse, I. Biaggio, "Three-color nonlinear optical mixing for the determination of the refractive index dispersion of a tellurite glass," *Appl. Phys. Lett.* 97, 131104 (2010).
- B. Breiten, I. Biaggio, F. Diederich, "Nonplanar Push-Pull Chromophores for Opto-Electronic Applications," *CHIMIA International Journal for Chemistry* 64(6), 409-413 (2010).
- H. Najafov, B. Lyu, I. Biaggio, V. Podzorov, "Two mechanisms of exciton dissociation in rubrene single crystals," *Appl. Phys. Lett.* 96, 183302 (2010).
- Z. Jin, I. Biaggio, J. Toulouse, "Ab initio study of linear and nonlinear optical properties of mixed tellurite-chalcogenide glasses," *J. Phys.: Condens. Matter* 22, 165903 (2010).
- M. Scimeca, I. Biaggio, B. Breiten, F. Diederich, T. Vallaitis, W. Freude, J. Leuthold, "Vapor deposition of organic molecules for ultrafast all-optical switching on silicon," *Optics and Photonics News* 20 (12), 39 (2009).
- T. Vallaitis, S. Bogatscher, L. Alloatti, P. Dumon, R. Baets, M. L. Scimeca, I. Biaggio, F. Diederich, C. Koos, W. Freude, J. Leuthold, "Optical properties of highly nonlinear silicon-organic hybrid (SOH) waveguide geometries," *Opt. Expr.* 17 (20) 17357 (2009).
- J. Leuthold, W. Freude, J.-M. Brosi, R. Baets, P. Dumon, I. Biaggio, M.L. Scimeca, F. Diederich, B. Frank, C. Koos, "Silicon Organic Hybrid Technology: A Platform for Practical Nonlinear Optics," *Proceedings of the IEEE* 97 (7) 1304 - 1316 (2009).
- C. Koos, P. Vorreau, T. Vallaitis, P. Dumon, W. Bogaerts, R. Baets, B. Esembeson, I. Biaggio, T. Michinobu, F. Diederich, W. Freude, J. Leuthold, "All-optical high-speed signal processing with silicon-organic hybrid slot waveguides," *Nature Photonics* 3, 216 - 219 (2009).